STRIPED BASS PREDATION ON JUVENILE SALMONIDS AT THE WOODBRIDGE DAM AFTERBAY, MOKELUMNE RIVER CALIFORNIA

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INTRODUCTION

Striped bass, *Morone saxatilis*, were introduced to the Pacific Coast of North America in 1879. This introduction was so successful that by 1888 a commercial fishery for the bass began in the Sacramento-San Joaquin Delta and they are now observed from south of the Mexican border to southern British Columbia (Moyle 2002). Striped bass eat a wide variety of invertebrates and fishes (Stevens 1966, Moyle 2002) including salmonids (Shapovalov 1936; Morgan and Gerlach 1950; Thomas 1967). In Coos Bay, Oregon, the decline of fall-run Chinook salmon, *Oncorhynchus tshawytscha*, coincided with large populations of striped bass and loss of spawning habitat. Reduced striped bass populations and improved habitat coincided with a salmon population recovery (Johnson et. al. 1992).

Chinook salmon and other fishes that utilize the tributaries and bays of the Sacramento/San Joaquin estuary have experienced a similar decline. The key to facilitate the recovery of these fishes is to identify and remedy significant causes for this decline.

In April and early May of 1993, after numerous reports of striped bass in the Woodbridge Irrigation District Dam (WIDD) afterbay, East Bay Municipal Utility District (EBMUD) began a monitoring program of striped bass and their predation on salmon in the lower Mokelumne River (LMR) within this afterbay. Monitoring has consisted of angling and seasonal electrofishing surveys immediately below this seasonal reservoir and has expanded to quarterly electrofishing further downstream as well as gastric lavage of captured striped bass.

Study Site

The LMR is an approximate 54-km reach of regulated river between Camanche Dam and its confluence with the Sacramento-San Joaquin Delta (Fig. 1). The drainage area below Camanche Dam consists of 87 km^2 of mostly agricultural and urbanized land (Anderson et al. 1993). Lake Lodi supplies a gravity-fed agricultural irrigation system and is annually filled from April through October. At least 36 fish species have been observed in the LMR since monitoring began in 1996 (Merz 2002). Woodbridge Irrigation District Dam (WIDD) has been in operation since the late 1800's and presently provides passage of adult and juvenile salmonids by fish ladder and a screening facility (Fig. 2). Monitoring is performed by video within the ladder and screw and fyke trap seasonally. While several other fish utilize the ladder to negotiate the dam, striped bass have not been observed above the reservoir since monitoring began in 1990 (Workman 2002).

METHODS

Electrofishing sampling was performed for 3 days the 1st week of January, April, August, and October 1998 through 2000. Sampling occurred between 0900 and 1500 hr with a 5.5 m electrofishing boat at representative habitats from each reach. All specimens were measured in the field to the nearest 1 mm fork length (FL). Stomachs of fish greater than 200 mm FL were evacuated following the methods described in Bowen (1983), Light et al. (1983), and Giles (1980). Stomach samples were immediately preserved in an 80-85% ethyl-alcohol solution, packed in ice, and transported to the laboratory for analysis. Random angling surveys were performed at the base of WIDD during daylight hours from 1993 to present and stomach content analysis was performed as stated above.

Striped bass diets were determined by stomach content analyses following procedures outlined by Bowen, in Nielsen and Johnson (1983). Consumption of juvenile salmon by striped bass in the WIDD afterbay was estimated for May through June 1993, from the underwater video data.

Methods developed by Johnson et al. (1989) were followed to evaluate striped bass predation on Chinook salmon. Losses of juvenile salmon were estimated as the product of the estimate of striped bass abundance and numbers of salmon juveniles consumed per striped bass.

Striped bass abundance was estimated from an underwater video survey conducted on 5/27/93; daily observations of illegal fishing activity reported by monitoring staff; and, the catch data from 7 angling surveys conducted in May and June1993 by California Department of Fish and Game (CDFG) and EBMUD.

A formula developed by Bajkov (1935) and used by Johnson et. al. (1993) was modified for estimating the consumption of juvenile salmon per predator: $C=KA$, where (C) is daily consumption, (K) is the turnover coefficient (24hrs./n, the number of hours for complete gastric evacuation based on average monthly water temperatures), and (A) is the average stomach content. The turnover coefficient was modified to reflect the digestion time (based on temperature) where even general identification of a food item was not possible but complete evacuation had not occurred. Water temperature was recorded hourly in the afterbay and the daily average was calculated and used to determine "evacuation" (digestion) rates for chinook salmon in striped bass stomachs. This information was combined with the stomach analysis data and used to estimate "daily ration".

Juvenile salmon abundance was estimated from an 8 ft diameter (2.4m) Archimedes rotary screw trap operating in the WIDD afterbay (Fig. 2). Temperature data was collected using a recording thermograph situated in the live car of the screw trap. A complete description of the methods and results of the temperature monitoring and juvenile salmon abundance work can be found in Vogel and Marine (1994).

RESULTS

During the monitoring period, 572 striped bass were captured. Striped bass FL ranged from 75-955 mm (Fig. 3-4). Highest concentrations among all sample sites were observed at WIDD (Fig. 5).

Stomach content analysis was performed on 153 striped bass collected by angling surveys and 54 from electrofishing. The results of gastric lavage analysis are provided in Figures 6-9.

Striped bass abundance in the WIDD afterbay was estimated between 200 and 500 fish for the May –June 1993 study period. Average daily water temperature was 15^{o}C during this time. An estimated digestion time when a salmon could no longer be identified was approximately 24 hours at 15^{o}C. For these parameters, 1.8-3.3 juvenile Chinook salmon could be consumed per striped bass each day (Fig. 10). Based on positively identified chinook salmon from striped bass stomachs, the results suggest the loss of naturally-produced Mokelumne River salmon to striped bass predation in the afterbay was between 19,824 fish and 49,560 fish (11%-28% of the estimated 1993 Mokelumne river natural production) (Fig. 10). Combining positively identified salmon with suspected salmon from sampled striped bass stomachs yields loss estimates as high as 92,120 fish (51.1%) for the 1993 outmigration.

A loss of 11% of the natural production at any one location in a river system is extremely high. High predation rates on outmigrating salmonids are not uncommon at engineered structures in other river systems. These conditions may have been exacerbated by the flow schedule in 1993. However, data from the 1998- 2000 electrofishing surveys suggests this is an ongoing impact on the Mokelumne River salmon population and possible solutions should be addressed.

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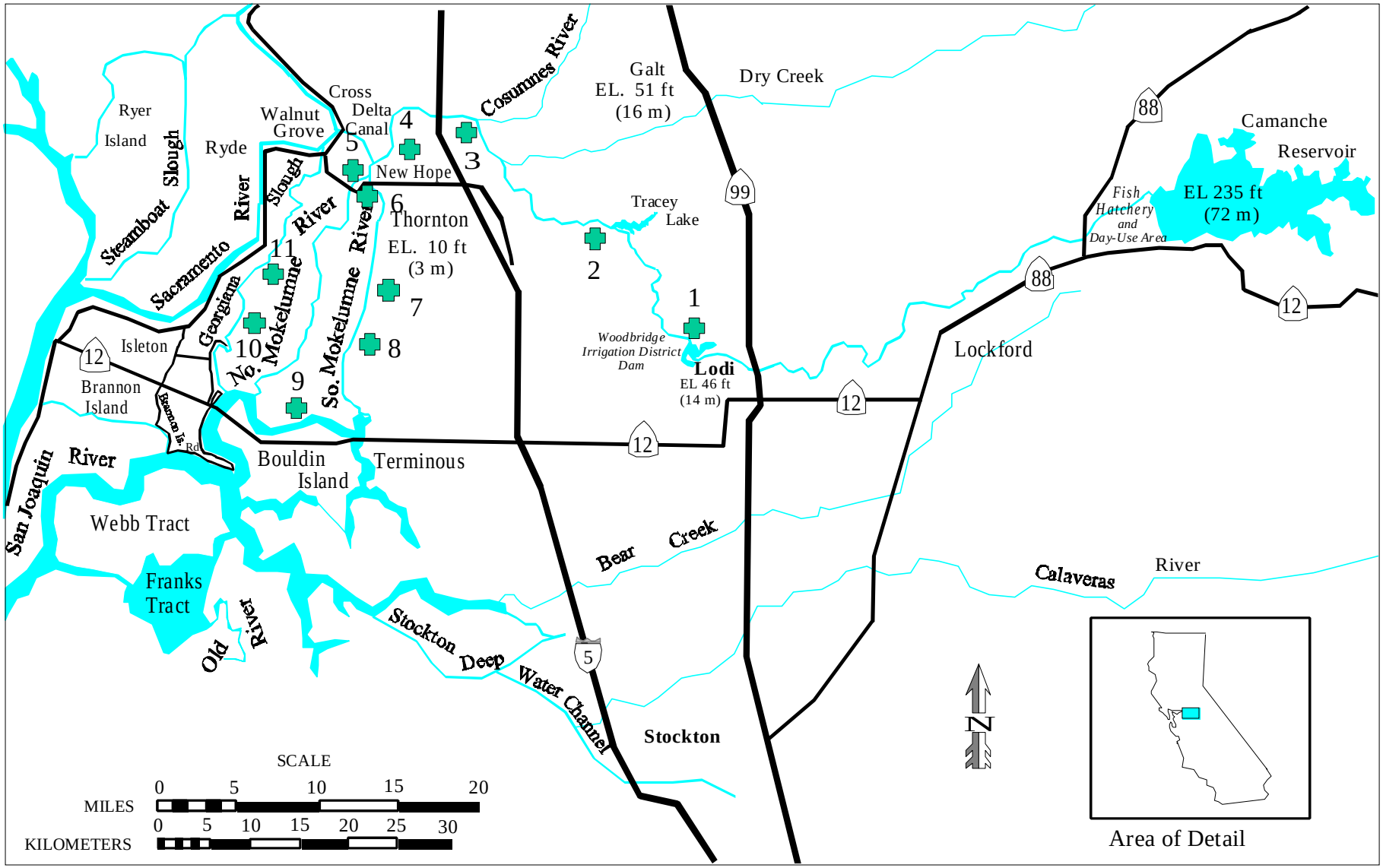

Figure 1. The lower Mokelumne River and associate portions of the Sacramento-San Joaquin Delta, California. Crosses indicate electrofishing sampling sites.

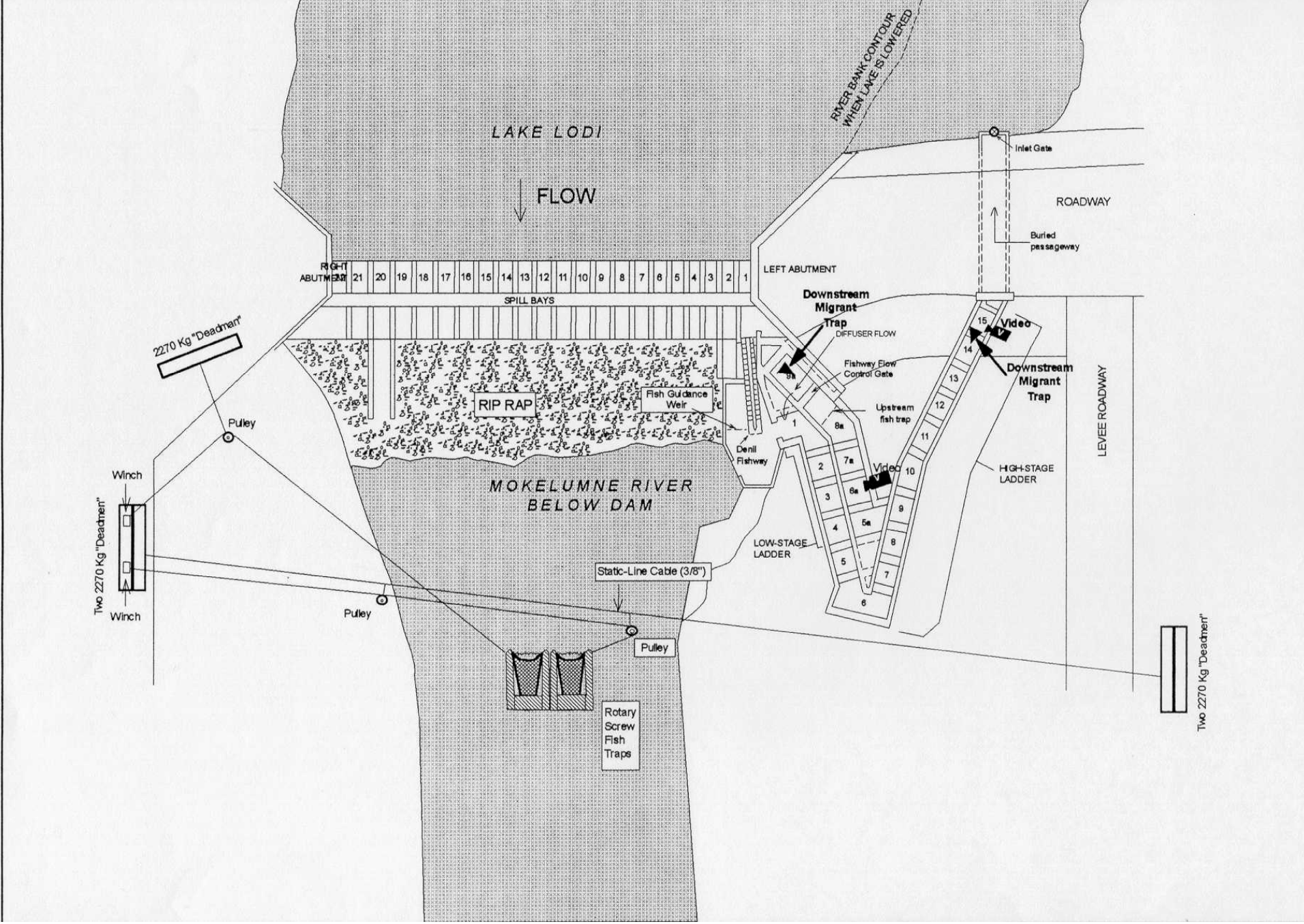

Figure 2. Diagram of Woodbridge Irrigation District Dam and afterbay, Lower Mokelumne River, California.

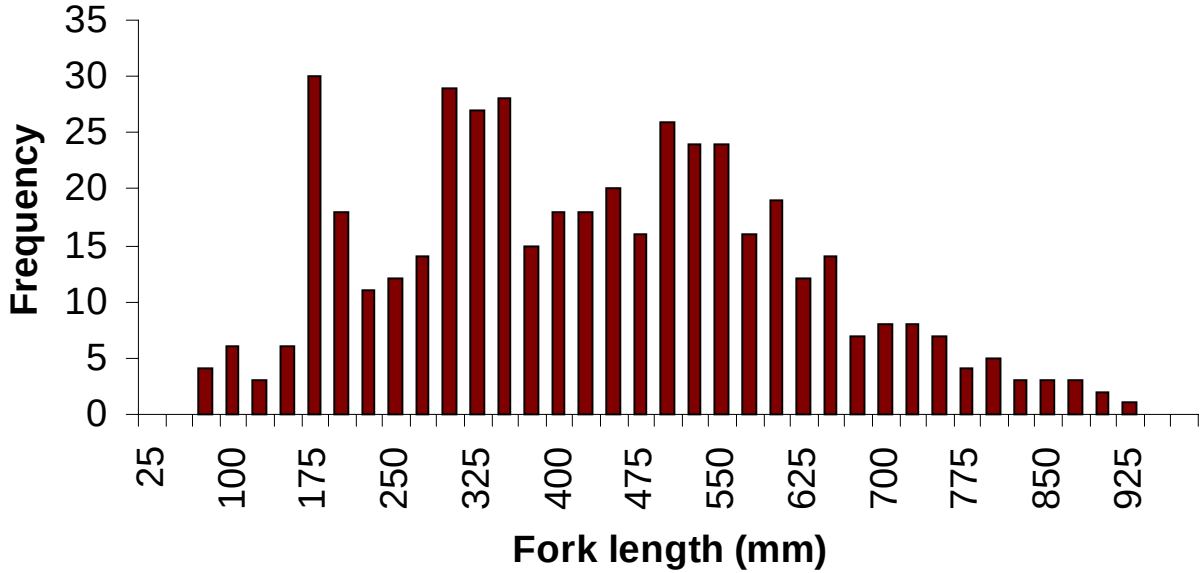

Figure 3. Length frequencies of striped bass collected by electrofishing at the Woodbridge Irrigation District Dam afterbay, Mokelumne River, California, 1998-2000.

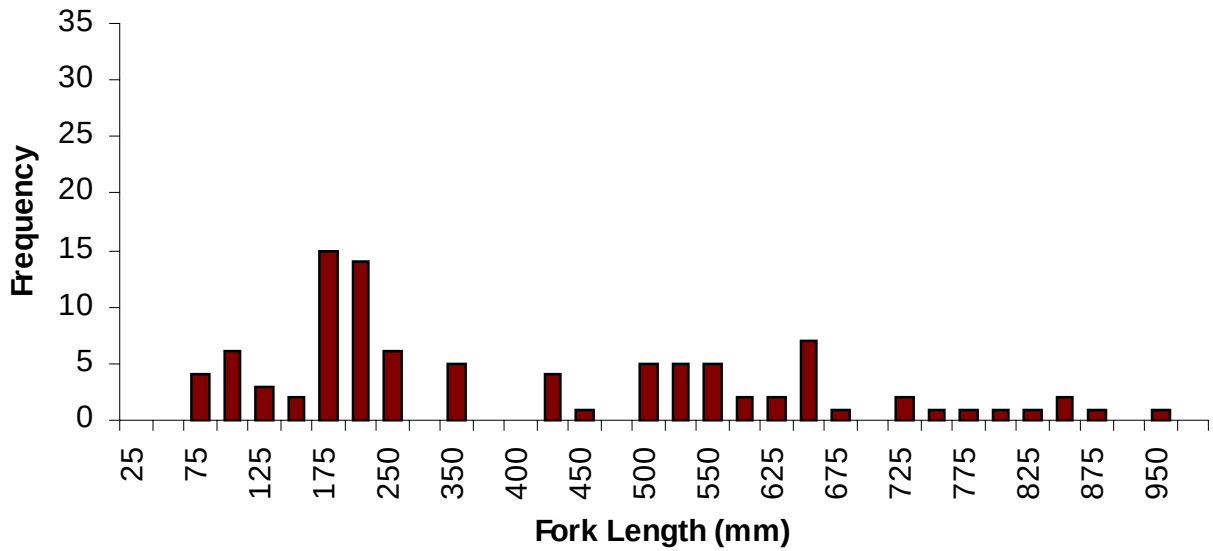

Figure 4. Length frequencies of striped bass collected by electrofishing downstream of the Woodbridge Irrigation District Dam afterbay, Mokelumne River, California, 1998-2000.

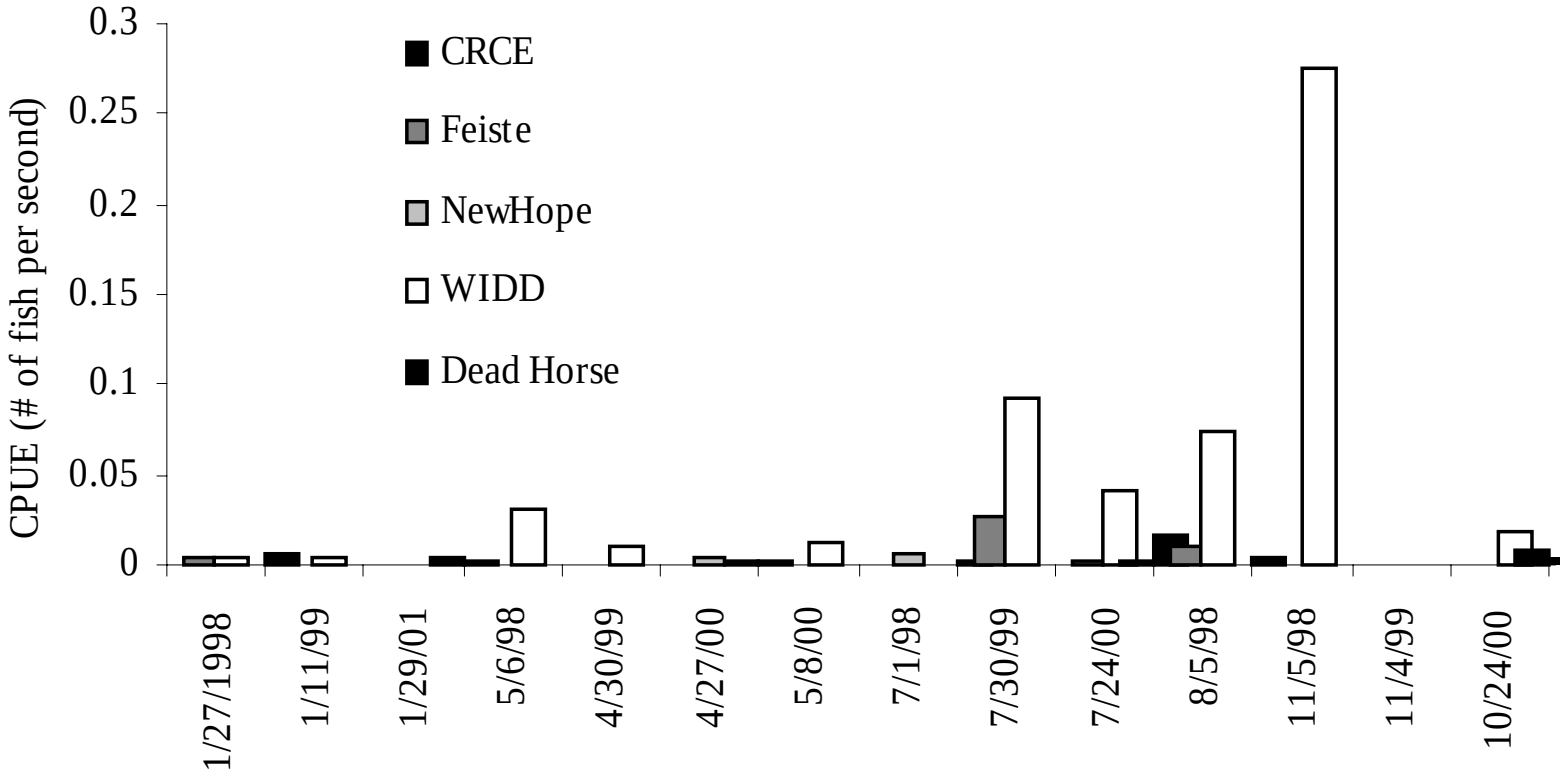

Figure 5. Catch per effort unit of striped bass by electrofishing on the lower Mokelumne River, California, 1998 – 2000. Woodbridge Irrigation District Dam (WIDD) is Site 1 on Figure 1; Feiste is Site 2; Cosumnes River Confluence (CRCE) is Site 3; New Hope is Site 4; Dead Horse is Site 5. No striped bass were observed at Sites 6-11.

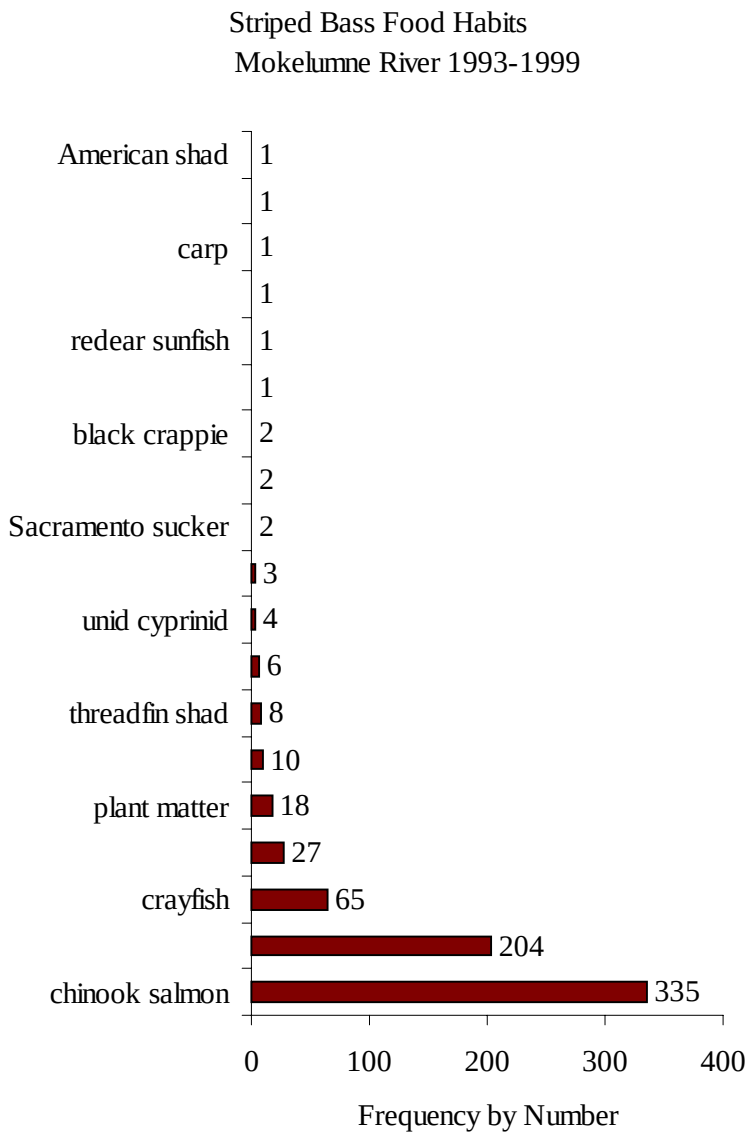

Figure 6. Mokelumne River striped bass food habits summary, frequency by number. Pooled data from all surveys, at all sites. N = 199

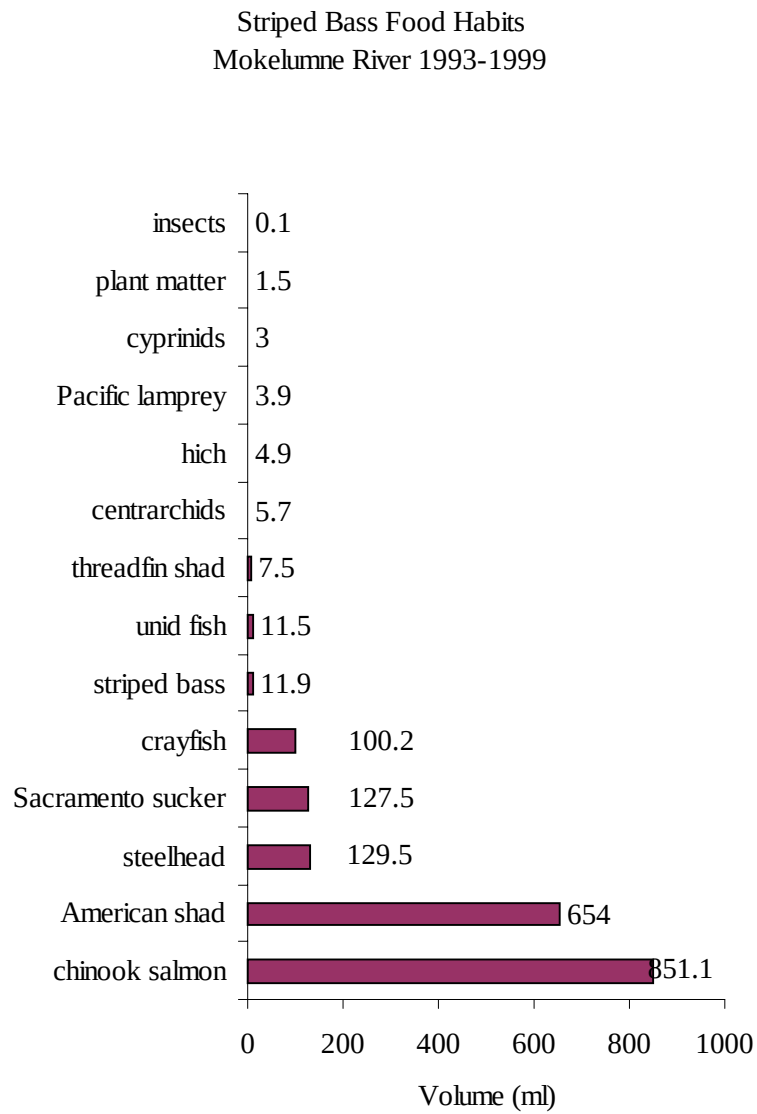

Figure 7. Mokelumne River striped bass food habits summary, frequency by volume. Pooled data from all surveys at all sites. N = 73

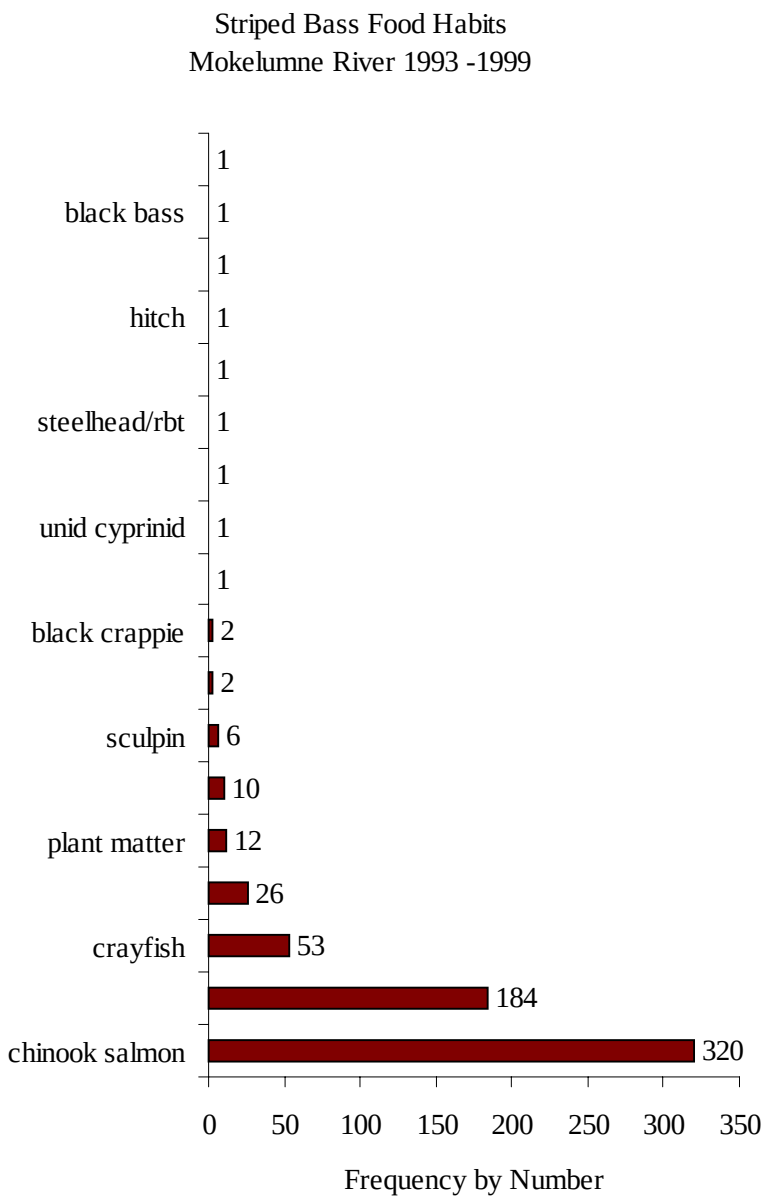

Figure 8. Frequency of striped bass prey items by number, collected from all surveys in the Woodbridge Dam Afterbay. n = 176

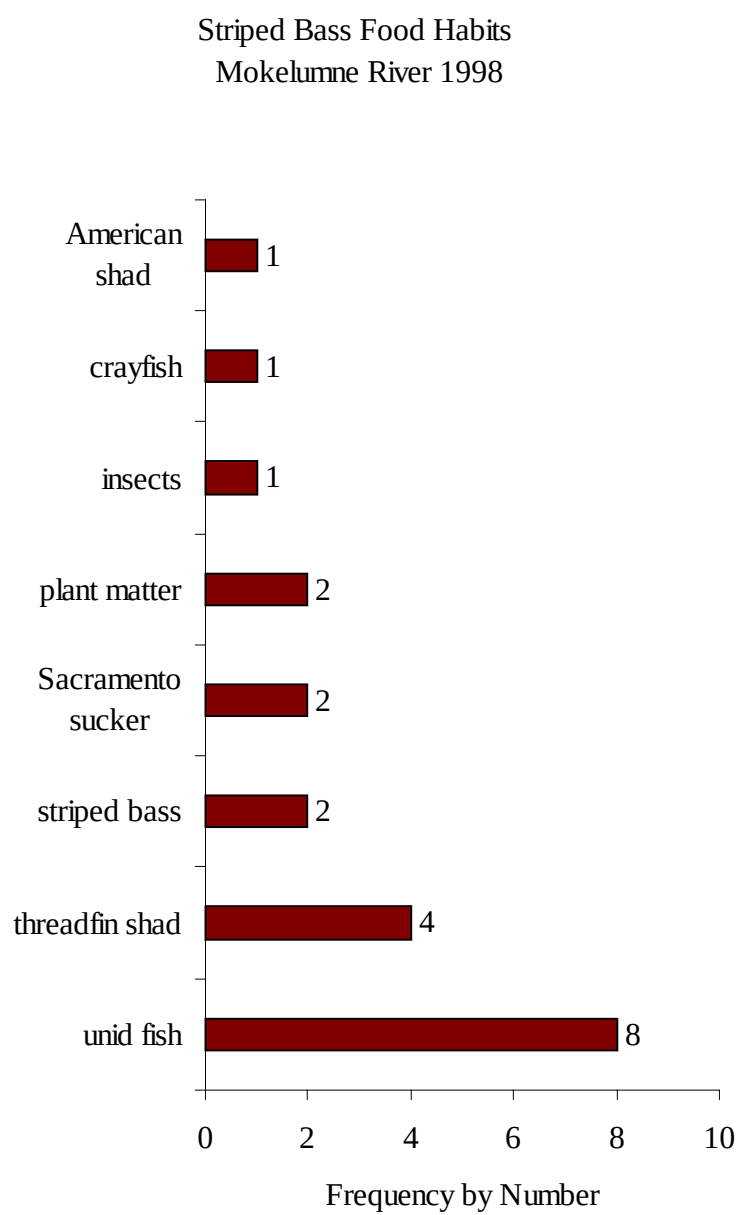

Figure 9. Frequency of striped bass prey items by number, collected from all survey sites below Lower Sacramento Road Bridge. n = 22

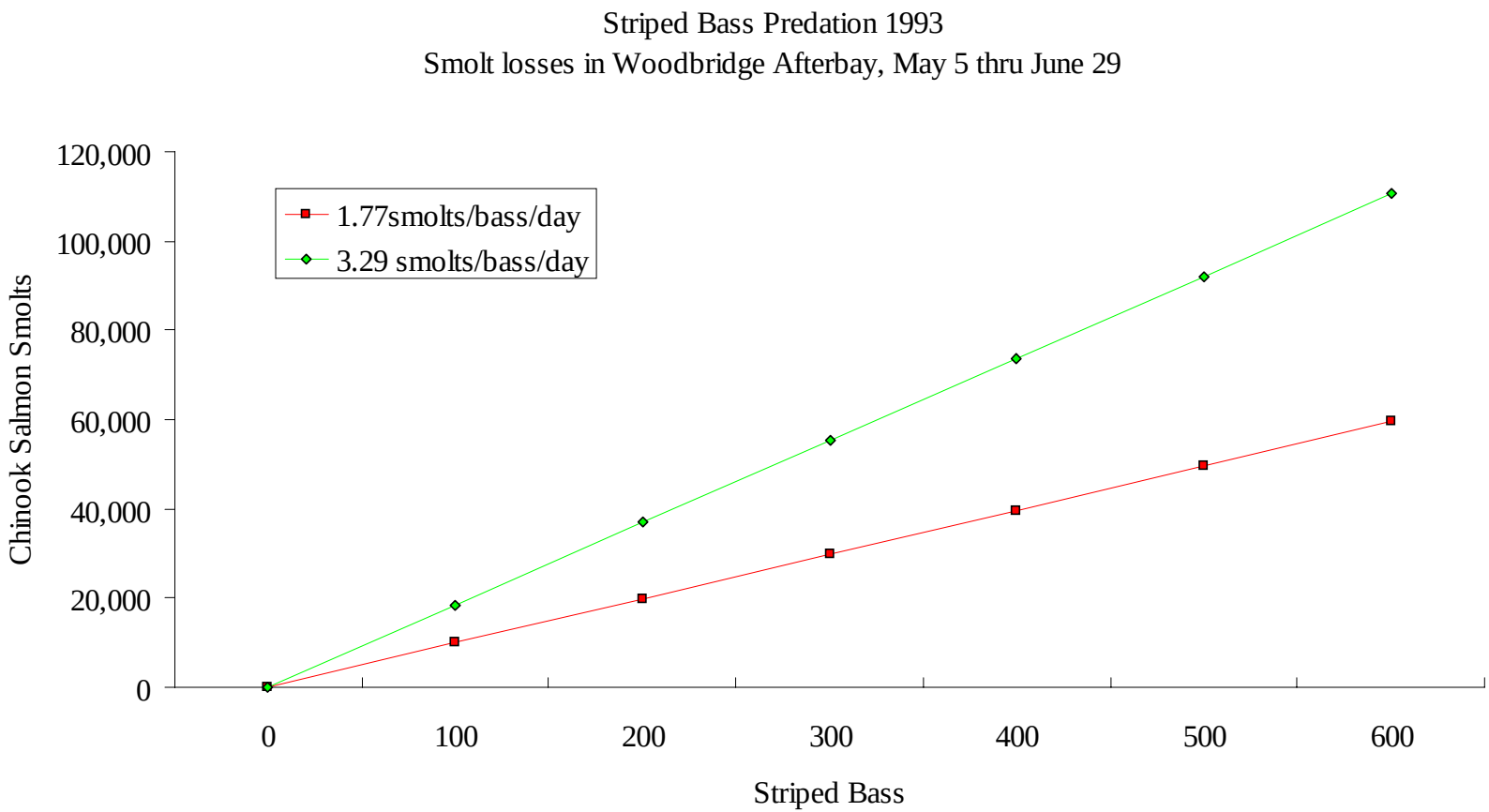

Figure 10. Estimated number of juvenile Chinoook salmon consumed by striped bass in the Woodbridge Irrigation District Dam afterbay, lower Mokelumne River, California. Information taken from the 1993 data series.